Staff Note: This annotated resource list highlights background resources that KEC staff has reviewed in the past several months. Although not intended as a comprehensive summary of either the literature or the content in each paper, this list does highlight information deemed relevant to the broad issue of climate change policy and the discussion of the Greenhouse Gas Policy Committee. Note that we have focused primarily on resources that appear to be reasonably objective (e.g., from governmental or educational institutions); however, we also include two reports prepared by advocacy groups that are, arguably, less objective.

To date, the following reports/papers are highlighted in this document:

1. *The Economics of Climate Change: A Primer,* Congressional Budget Office (CBO) Study, April 2003 (available at CBO's web site: www.cbo.org).
2. *Climate Change Legislation Design White Paper: Appropriate Roles for Different Levels of Government,* Committee on Energy and Commerce Staff, February 2008 (http://energycommerce.house.gov/Climate%5FChange/).
3. *Climate Change Legislation Design White Paper: Competitiveness Concerns/Engaging Developing Countries,* Committee on Energy and Commerce Staff, January 2008 (http://energycommerce.house.gov/Climate%5FChange/).
4. *Climate Change Legislation Design White Paper: Scope of a Cap-and-Trade Program,* Committee on Energy and Commerce Staff, October 2007 (http://energycommerce.house.gov/Climate%5FChange/).
5. *Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs,* Congressional Budget Office, June 2000 (available at CBO's web site: www.cbo.org).
6. *A Question of Balance: Weighing the Options on Global Warming Policies,* William Nordhaus, Yale University Press, 2008 (pre-publication version: http://nordhaus.econ.yale.edu/Balance_2nd_proofs.pdf).
7. *Global Climate Change: A Challenge to Policy*, Kenneth J. Arrow, Economist's Voice, 2007 (available from The Berkeley Electronic Press at www.bepress.com/ev)
8. *Policy Options for Reducing CO2 Emissions,* Congressional Budget Office (CBO) Study, February 2008 (available at CBO's web site; www.cbo.org).
9. *Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions,* Congressional Budget Office (CBO) Study, September 2006 (available at CBO's web site: www.cbo.org)
10. *National Climate Policy: Choosing the Right Architecture,* Robert Repetto, Yale School of Forestry & Environmental Studies, June 2007
11. *Global Climate Change: What is to be Done? An Economic Perspective,* Robert N. Stavins, Harvard Electricity Policy Group (HEPG), June 2007 (available at HEPG's web site: http://www.hks.harvard.edu/hepg)
12. *What Will it Cost to Protect Ourselves from Global Warming?: The Impacts on the U.S. Economy of a Cap-and-Trade Policy for Greenhouse Gas Emissions,* Nathaniel Keohane and Peter Goldmark, Environmental Defense Fund, 2008 (http://www.edf.org/documents/7815_climate_economy.pdf).
13. *The Economic Costs of the Lieberman-Warner Climate Change Legislation,* The Heritage Foundation, 2008 (available online at http://www.heritage.org/research/EnergyandEnvironment/upload/cda_0802.pdf)

The Economics of Climate Change: A Primer, **Congressional Budget Office (CBO) Study, April 2003 (available at CBO's web site: www.cbo.org).**

- Overview of climate change issues, focused primarily on economic studies. Summarizes the current state of climate science and provides conceptual framework for addressing climate change as an economic problem.
- Historical and statistical evidence suggests that a warmer global climate could produce both harmful and beneficial effects.
    - effects will vary by region (and be even more uncertain than the effects globally)
    - people in developing countries are probably more vulnerable to damaging effects than those in developed countries, largely because they have fewer resources for coping with impacts; also some of these countries have large populations concentrated either in low-lying regions vulnerable to a rise in sea level or flooding or in marginal agricultural lands vulnerable to drought
    - very rapid changes in climate could have drastic impacts on plants, animals; warming would probably increase natural range of insect-borne diseases
    - disruption of deep ocean currents that strongly influence global climate (thermohaline circulation)
- Scientists and economists raise many questions about the potential economic threat posed by a changing climate. For example:
    - How much will a given change in GHG concentrations affect global climate? How will that change be distributed throughout the world, and how rapidly will it occur?
    - How rapidly will the world's economies and populations grow? How will policies to control GHG emissions affect accumulation of GHG's in atmosphere? How will future generations value the effects of averting climate change?
- Policymakers for the foreseeable future will continue to face great uncertainty in determining the potential costs and effects of different policies to address the problem of climate change.
- **Chapter 3, The Economics of Climate Change,** provides a good overview of basic economic theory and conceptual framework for policy discussion:
    - Earth's atmosphere and climate are part of the stock of natural resources available to people to satisfy their needs, wants over time.
    - **Tragedy of the commons:** if resources are free for the taking, people will tend to overuse them; if nobody owns them, nobody will take care of them. Everyone wants to use free resources but will degrade them if they do, to the detriment of all.
        - People want to use the atmosphere to absorb GHGs so that they may benefit from cheap food and timber and from plentiful fossil energy. In the long run, however, that use may significantly degrade the climate.
    - "In sum, policymakers may be faced with the extraordinarily complicated task of managing a resource that no one owns, that everyone depends on, and that provides a wide range of very different—and often public—benefits to different people in different regions over very long periods..." (p.25)
    - Reaching collective agreement on policy is an immense challenge because everyone has an incentive to "free ride."
        - Although a successful agreement need not entail equal action by all parties, any agreement will break down if some parties sacrifice to meet an overall goal and others cheat (increase their emissions in violation of goal).
        - Further complicating any collective agreement is the fact that governments aren't usually subject to the market forces that drive competitive firms to efficiently provide goods and services that consumers most want to buy; instead, they tend to represent

coalitions of private and bureaucratic interests that often engage in **rent-seeking behavior**—attempting to redirect the economy's resources to their own advantage.

- Effective climate policy would balance the benefits and costs of using the atmosphere and climate and would distribute them among people in an acceptable way.
  - in other words, it involves making investments today to yield future returns in the form of a beneficial climate—with due regard for the scientific and economic uncertainty involved.
  - the appropriate course of action—and appropriate level of investment—depends on how one balances the competing interests of present and future generations and how one accounts for the uncertainty involved
    - **Discount rate** discussed on p. 27 and in Box 1 on page 28-29
- **Integrated (economic) assessments of climate change policies conclude that modest restrictions on emissions today would yield net benefits in the future**, but extensive restrictions would crowd out other types of investment. (Box 2, p. 30-31, provides an example of integrated assessment.)
  - the most cost-effective way to respond to the risk of climate change is through a gradual process of adjustment
- **Coping with uncertainty:** "No one wants to undertake extensive, expensive actions to solve a problems that turns out to be relatively mild—or to take no action to solve a problem that later proves catastrophic. Policymakers are thus forced to hedge their bets and prepare for more than one possible outcome..." (p. 32).
  - **Climate policy will inevitably involve a sequence of decisions;** at each stage, policymakers would determine near-term plan, based on best information available; plan would entail both research to further improve knowledge and action to reduce risk.
  - **Irreversibility involved in both mitigation and impacts:** on the one hand, expensive investments to reduce emissions will be impossible to recoup if warming proves modest or largely beneficial; on the other hand, emitted GHGs are likely to be difficult to withdraw from the atmosphere if warming proves to be very damaging.

- **Chapter 4, Trade-offs Among Policy Options,** is yet another good overview of command-and-control regulation, emissions taxes or fees, and emissions permits.
  - Includes a discussion (p. 36-37) of the argument that regulating GHGs might not be costly because energy conservation pays for itself; although there may be specific roles for government, "economists find it difficult ... to determine the circumstances in which standards clearly induce people to reduce their use of energy at no cost or with net savings." See footnote 7.
  - Flexibility of regulation: the fact that it doesn't matter *which* GHG is controlled, *where* it is controlled, or even—to some extent—*when* it is controlled (this year or next) allows for a great deal of flexibility in regulation (which reduces costs)
  - "In contrast to direct controls, market-based systems give firms and households stronger incentives to find low-cost ways to reduce emissions through behavioral changes and innovative technologies." (p. 35)
  - Consumers will bear most of the direct costs in the long run.
  - Permit system (e.g., cap-and-trade) can encourage rent-seeking behavior:
    - for example, fossil fuel suppliers might advocate a system in which permits were given away free of charge, so that they would receive the revenue from the higher prices that result from emissions limits

- **Revenue from regulation:** if the government taxes emissions or auctions permits, it receives the revenue, all or some of which could be redistributed in various ways: (1) cutting other taxes, (2) reducing government debt, (3) funding new programs
  - not all revenues from emissions tax or auctioned permits would be available for redistribution, as regulation is likely to curb economic activity, reducing tax revenues, and also raise government's costs for energy and energy-intensive goods (see footnote 11).
  - "Taken together, the literature on environmental taxation and revenue recycling suggests that using revenues from emissions taxes to finance a general reduction in taxes on all sorts of investment would be more cost-effective than using them to target investments for environmental purposes." (p. 41)
- **Regulation and innovation:** ultimately, cost of controlling GHG emissions will depend on technological developments over the next century.
  - taxes and auctioned permits are more likely to induce more innovation
  - in contrast, companies have less incentive to innovate under a system of freely allocated permits—and even less under command-and-control regulatory system
- **Ancillary benefits** such as reduction in traditional pollutants could offset a significant portion of the costs associated with regulating GHG emissions.
  - Side benefits would include lower costs for compliance with existing (and pending) regulations, as well as health-related benefits
  - Such ancillary benefits would be even greater in developing countries where conventional pollution problems remain unaddressed

- **Chapter 5, International Coordination of Climate Policy** discusses issues associated with international cooperation. Provides history of U.N. Framework and Kyoto Protocol
  - Fundamental differences are between more and less affluent countries.
    - Developed countries have contributed bulk of historical emissions; developing countries will account for majority over the next century
    - Developing countries may be more vulnerable to damage from climate change.
  - Development of effective coordination of international climate policy is likely to be gradual (took 50 years to get WTO in current form).
    - Countries have little incentive to act unilaterally; every nation has an incentive to free ride.
  - Formal structures for cooperation: treaties or executive agreements.
    - under international law, both types are considered binding
  - Compliance: few existing international agreements have provisions for enforcement; some observers argue that international enforcement of climate change policy will require penalties involving trade and thus WTO will be involved.
- **Appendix** provides overview of types of economic models, strengths and weaknesses.

Climate Change Legislation Design White Paper: Appropriate Roles for Different Levels of Government, Committee on Energy and Commerce Staff, February 2008 (http://energycommerce.house.gov/Climate%5FChange/).

- Assumes the primary tool at the Federal level is a national, economy-wide cap-and-trade program that reduces GHG emissions by 60 to 80 percent by 2050.
- **Provides a good summary of regional, state, and local climate change programs.** These include:

  - California (2006) adopts economy-wide cap on GHG emissions (AB 32, the Global Warming Solutions Act), requiring state to reduce GHGs to 25% of 1990 levels by 2020 and 80% by 2050.
  - 16 states have adopted GHG emissions reduction targets, 6 of which are codified
  - 800 mayors have signed the U.S. Conference of Mayors Climate Protection Agreement to reduce GHG emissions 7% below 1990 by 2012
  - Western Climate Initiative (2007) established regional GHGH reduction target, shared by 7 states (AZ, CA, MT, NM, OR, UT, WA). Regional cap-and-trade will be proposed July 2008
  - Midwestern Regional Greenhouse Gas Accord (2007) commits another 6 states (IL, IA, KS, MI, MN, WI) to near- and long-term GHG reduction goals with multi-sector cap-and-trade system
  - Regional Greenhouse Gas Initiative (RGGI), formed in 2003, established power-sector emissions trading program. First 3-year compliance period begins in 2009, with initial public auctioning of allowances in June 2008
- Also provides a good summary of **Clean Air Act,** an environmental law that assigns different roles in different parts of the program to Federal, State, Tribal, and local governments.
  - Responsibility for enforcement of controls on *stationary sources* is generally shared by EPA and State, Tribal, and local governments.
  - For *mobile sources,* the Act requires EPA to set standards for new vehicles and prohibits States from adopting more stringent standards (except in limited circumstances—that is, CA).
- **Acid Rain Trading Program** is implemented and enforced by EPA, with States enforcing monitoring requirements. (Each state has the right to impose more stringent requirements on power plants within its borders.)
- **Regarding scope of problem:** "One key factor that distinguishes climate change from other pollution problems our country has tackled is that *local* greenhouse gas emissions do not cause *local* environmental or health problems, except to the extent that the emissions contribute to *global* atmospheric concentrations. This characteristic of greenhouse gases stands in contrast to most pollution problems, where emissions adversely affect people locally where the emissions occur. The global nature of climate change takes away (or at least greatly minimizes) one of the primary reasons many national environmental programs have provisions preserving State authority to adopt and enforce environmental programs that are more stringent than Federal programs: States have a responsibility to protect their own citizens. This reality does not, however, lead to the conclusion that States, Tribes, or localities should not do anything to address climate change." (p.12)
- **Regarding effects on level of GHG emissions and cost to reduce:** "With most Federal environmental programs, more stringent local programs reduce national emissions. That result is not necessarily achieved with a Federal cap-and-trade program. State, Tribal, and local programs may either decrease or not change national greenhouse gas emissions, and either increase, not change, or decrease the cost of achieving reductions." (p.12)
- **Appropriate roles for state government** in comprehensive, national approach will depend on design of federal approach. State-level policies such as building codes or programs that focus on land use are viewed as appropriate.

***Climate Change Legislation Design White Paper: Competitiveness Concerns/Engaging Developing Countries,* Committee on Energy and Commerce Staff, January 2008 (http://energycommerce.house.gov/Climate%5FChange/).**

- Focuses on potential U.S. legislative provisions that could encourage developing countries to participate in GHG control.

- Assumes U.S. will have enacted legislation by end of 2009, the time at which the Bali Action Plan aims to have specified emissions obligations for both developed and developing nations that will begin in 2013.
- Argues that U.S. policy should include incentives for developing nations such as China and India to curb their emissions because (1) limiting GHG emissions in U.S. and other developed countries won't have desired impact on climate unless key developing countries also join in; (2) without corresponding action by global trade partners, U.S. industry and jobs might relocate to (or expand operations in) countries without GHG limits, to the detriment of both the environment and U.S. economy; and (3) past action on climate change suggests that Congress would be unlikely to adopt legislation committing U.S. to reductions without action by developing countries.
- Provides a good overview of relative emissions of different countries (historical and projected).
    - The U.S., the EU-25, China, Russia, India, and Japan accounted for more than 60% of total emissions in 2000.
    - The International Energy Agency, in 2007, projected that global energy demand would increase by more than one-half by 2030 and that developing countries would account for 74% of the increase in primary energy use.
- Must U.S. "go first? Some contend that developing nations view a prior U.S. commitment to reduce GHG emissions as "absolute prerequisite" to limiting their own emissions.
- Outlines **three legislative approaches** intended to ensure developing nations curb emissions, so that "environmental objectives of climate change legislation can be achieved and the competitiveness of American industry is not adversely affected." Any option will have to pass muster before the World Trade Organization (WTO).
    - **Border Adjustments:** trade-related policies that use tariffs, taxes, or other mechanisms to require imports to be accompanied by emissions allowances.
    - **Performance Standards:** a "non-market-based" approach, relying on emissions standards or carbon intensity-based regulations that would apply to all energy intensive materials sold in U.S., regardless of origin.
        - One question is whether such regulation would be separate from, or in addition to, obligations up a U.S. cap-and-trade regime.
    - **Carbon market Design:** In establishing U.S. carbon market, Congress would stipulate conditions to encourage developing nations to limit their emissions.
        - offer emissions premiums for countries that sign up to emission caps early.
        - levy mandatory "multipliers" on emissions credits generated in uncapped countries (for example, Congress could stipulate that it would take more than 1 credit to offset ton of emissions)
        - instruct the Executive Branch to negotiate carbon market access agreements with other countries.

***Climate Change Legislation Design White Paper: Scope of a Cap-and-Trade Program,* Committee on Energy and Commerce Staff, October 2007 (http://energycommerce.house.gov/Climate%5FChange/).**

- Congressional Committee has concluded that:
  - U.S. needs to reduce GHGs by 60% to 80% below 2005 levels by 2050.
  - U.S. needs **economy-wide,** mandatory program.
  - Central component of program will be a cap-and-trade program.
- Program will cover 6 major greenhouse gases.
- Direct emissions are attributable to the following economic sectors: Electric Generation (34% of U.S. emissions in 2005), Transportation (28%), Industrial (19%, mostly from production of steam and/or heat for industrial processes), Commercial (6%, mostly for heating, cooking, and equipment needs of businesses, government, organizations), Residential (5%, mostly for cooking and heating needs of private homes), Agricultural (8%, primarily direct methane and nitrous oxide emissions from various sources, including soil management practices).
- Excluding some sectors from the regulation not only increases burden on regulated sectors, but may allow a shift of emissions from covered to uncovered sources, often called **leakage.**
- Accurate accounting for emissions requires understanding the chain of economic activity associated with each type of GHG emissions and selecting one point in the chain (**point of regulation**) to be responsible for tracking emissions.
  - point of regulation can be set at one of several points: downstream (on entity that actually emits GHGs, e.g., coal-based power plants), upstream or midstream (entitity produces, imports, processes, or transports the fuel that, when used, emits GHGs)
- Includes sector-by-sector discussion of inclusion in program, threshold levels within sector, appropriate point of regulation. Highlights include:
  - **Electricity Generation Sector:** Covering units with nameplate capacity of 25 MW or greater would cover 4,900 units and 99.6% of emissions from sector.
  - **Transportation Sector:** downstream point of regulation is not workable; upstream regulation of refiners and importers would require them to turn in allowances to cover carbon content of fuel sold.
  - **Industrial Sector:** includes manufacturing, construction, and mining; hundreds of thousands of entities to regulate; establishing threshold for regulation would reduce number of covered entities, but still lots; upstream regulation seems to be preferable (see p. 16)
  - **Commercial Sector:** in addition to buildings (includes public sector), this sector includes landfills; possible that the same approach will not work for all types of sources in this sector; upstream or midstream point of regulation might provide broad coverage of emissions from buildings; discussion of landfills (p. 19).
  - **Residential Sector:** covering emissions in this sector raises same issues as in the commercial sector; to include in cap-and-trade, point of regulation would need to be upstream.
  - **Agricultural Sector:** approximately 2/3 of emissions were nitrous oxide, mostly from fertilizer application, and manure management; about 1/3 were methane (ruminant animal digestion) and manure management. Emissions from this sector don't lend themselves to regulation under cap-and-trade; EPA operates a methane capture program; possible inclusion of soil carbon sinks as offsets or credits in program.
- Desire to cover all emissions must be balanced against need for efficiently administered program.
- Sectors that should be covered in cap-and-trade: Electricity Generation (downstream), Transportation (upstream), Industrial (possible exclude low emitters; more info needed to determine point of regulation), Commercial and Residential (upstream would allow greater coverage).

***Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs,* Congressional Budget Office, June 2000 (available at CBO's web site: www.cbo.org).**

- Focuses on how the costs of U.S. policies to reduce GHGs would ultimately be distributed among households. Assumes upstream program to reduce emissions from 1998 levels by 15% (not clear by when). Table 5 shows changes in after-tax household income under 4 different "allowance-allocation/revenue-recycling scenarios":
    1) allowance giveaway combined with cut in corporate taxes: results in the most regressive income distributional effect, in that lower-income households' incomes would fall by 3.1% and highest-income households would increase by 1.8%
    2) allowance auction combined with lump-sum rebates: results in a progressive income distributional effect
    3) allowance giveaway combined with lump-sum rebate: regressive but not as much as scenario 1
    4) allowance auction combined with cut in corporate taxes: slightly less regressive than scenario 1
- Primary advantage of trading programs, compared to more traditional approaches that mandate specific pollution limits for all sources, is that they can lower the cost of achieving the reduction by giving participants some flexibility.
- U.S. Trading Programs: in addition to sulfur dioxide programs, federal government has successfully used trading programs to gradually lower (and phase out) the amount of lead in gasoline and to phase of the use of ozone-depleting chemicals.
- Regarding price signals in early markets: about 1.7% of 8.69 million sulfur dioxide allowances were auctioned "to ensure a supply of allowances for new utilities and, for early auctions, to provide a price signal for allowances in a nascent market" (footnote 9)
- Although allowance giveaway makes carbon limits more acceptable to regulated entities, auctioning generates revenue that government could use to cut existing taxes on capital and labor (taxes on capital discourage investment and saving, and taxes on labor can discourage people from working more and employers from using more labor).
- International trading programs would lower cost to U.S. of achieving carbon reductions
- Under a cap and trade, regulated entities would ultimately pass along the higher of doing business to consumers in the form of higher prices.
- Understanding distributional implications of different policy designs is important because the amount of wealth that a carbon trading policy would redistribute could be very large.
- Goals of equity and efficiency could conflict.

***A Question of Balance: Weighing the Options on Global Warming Policies,* William Nordhaus, Yale University Press, 2008 (based on pre-publication version that was available online in early 2008: http://nordhaus.econ.yale.edu/Balance_2nd_proofs.pdf. Note that the book has now been published by Yale University Press).**

- [Staff note: this study was one of the key references for material in "Climate Change Policy: Overview of Options to Reduce GHG Emissions," a powerpoint presentation at April 9, 2008, meeting of the GHG Policy Committee.]
- Uses tools of economics and mathematical modeling to analyze efficient and inefficient approaches to slowing global warming.
    - Underlying premise is that global warming is a serious societal issue; the scientific basis is well established.

- Chapter 1, "Summary for the Concerned Citizen," offers a clear, dispassionate summary of global warming issues and the economic approach to climate change policy. Some excerpts below:
    - "Societies have considerable experience in employing different approaches to changing energy production and use patterns. Economic history and analysis indicate that it will be most effective to use the market mechanism, primarily higher prices on carbon fuels, to give signals and provide incentives for consumers and firms to change their energy use and reduce their carbon emissions. **In the longer run, higher carbon prices will provide incentives for firms to develop new technologies to ease the transition to a low carbon future.**" (p. 4)
    - "... if a country wished to impose a carbon tax of $30 per ton of carbon, this would involve a tax on gasoline of about 9 cents per gallon. Similarly, the tax on coal-generated electricity would be about 1 cent per kWh, or 10 percent of the current retail price. At current levels of carbon emissions in the United States, a tax of $30 per ton of carbon would generate $50 billion of revenue per year." (p. 12)
    - "Our modeling results point to the importance of near universal participation in programs to reduce greenhouse gases. Because of the structure of the costs of abatement, with marginal costs being very low for the initial reductions but rising sharply for higher reductions, there are substantial excess costs if the preponderance of sectors and countries are not fully included. We preliminarily estimate that a participation rate of 50 percent, as compared with 100 percent, will impose an abatement-cost penalty of 250 percent. Even with the participation of the top 15 countries and regions, consisting of three-quarters of world emissions, we estimate that the cost penalty is about 70 percent." (p. 19)
    - "**Economics contains one fundamental inconvenient truth about climate-change policy: For any policy to be effective in slowing global warming, it must raise the market price of carbon, which will raise the prices of fossil fuels and the products of fossil fuels.** Prices can be raised by limiting the number of carbon-emissions permits that are available (cap-and-trade) or by levying a tax (or some euphemism such as a "climate damage charge") on carbon emissions. Economics teaches us that it is unrealistic to hope that major reductions in emissions can be achieved by hope, trust, responsible citizenship, environmental ethics, or guilt alone. **The only way to have major and durable effects on such a large sector for millions of firms and billions of people and trillions of dollars of expenditure is to raise the price of carbon emissions."** (p. 20)
    - "**Because of the political unpopularity of taxes, it is tempting to use subsidies for "clean" or "green" technologies as a substitute for raising the price of carbon emissions. This is an economic and environmental snare to be avoided."** (p. 21)
        - too many clean activities to subsidize: virtually everything from market bicycles to non-market walking has a low carbon intensity relative to driving
        - insufficient resources to subsidize all activities that are low emitters plus calculation of an appropriate subsidy for a particular activity would be a horrendously complicated task
        - encourages a pell-mell race for benefits—an environmental form of rent-seeking
        - **BUT it is economically appropriate to subsidize education, innovation, invention** (all public goods)
    - **"Whether someone is serious about tackling the global warming problem can be readily gauged by listening to what he or she says about the carbon price.** Suppose you hear a public figure who speaks eloquently of the perils of global warming and proposes that the nation should move urgently to slow climate change. Suppose that person proposes regulating the fuel efficiency of cars, or requiring high-efficiency light bulbs, or subsidizing ethanol, or providing research support for solar power—but nowhere does the proposal raise the price of carbon. You should conclude that the proposal is not really serious and does not recognize the

central economic message about how to slow climate change. **To a first approximation, raising the price of carbon is a necessary and sufficient step for tackling global warming. The rest is at best rhetoric and may actually be harmful in inducing economic inefficiencies."** (p. 23)

- **Optimal policy**—where incremental costs and benefits are balanced—would be relatively inexpensive, have substantial impact on long-run climate change (reduces global temperature rise relative to 1900 to 2.6°C in 2100 and 3.4°C in 2200)
    - **tax of $34 per metric ton of carbon in 2010** ($9.26 per ton of CO2), increasing in future years to $90 per ton in 2050 and $202 per ton in 2100
        - carbon tax of $20 per ton would raise coal prices by $10 per ton, about 40% of the mine-mouth price
        - carbon tax of $10 per ton would raise gasoline prices by 4 cents/gallon
    - net present value of optimal policy is $3 trillion (present value of abatement costs would be about $2 trillion, 0.1 percent of discounted world income – 2005 dollars).
        - more stringent targets (except for most ambitious) add relatively modest costs: e.g., constraining CO2 concentrations to double pre-industrial level has present-value cost of $0.4 trillion (limiting temp increase to 2.5°C adds $1.1 trillion to cost)
    - Optimal carbon tax indicates level of restraint on carbon emissions on the economically optimal path—where incremental costs and benefits are balanced
- **Important to avoid inefficient policies: for example, Stern and Gore proposals impose too-large reductions in the short run and too high costs to attain the same environmental objective.**
    - "Similar issues arise for policies that use technological standards in place of generalized market mechanisms. Two prominent proposals are to ban coal-fired power plants and to raise sharply fuel-economy standards for automobiles. Although both of these industries will require major adjustments if tight restraints are imposed on emissions, technology standards are blunt and inefficient instruments. Calculations of the carbon-tax equivalent of some fuel-economy proposals indicate that they are far above the optimal carbon tax and thereby impose larger costs than necessary to meet the same objectives." (p. 198)
    - Doesn't mean we should do nothing; rather, it implies that undertaking sharp emissions reductions within next two or three decades is not economically advantageous.
- **Economy-wide policies are much more efficient**—half participation has a 250% cost penalty.
- **Kyoto Protocol:** "the current Kyoto Protocol is seriously flawed both in its environmental rationale and in its economic impacts. The approach of freezing emissions for a subgroup of countries is not related to a particular goal for concentrations, temperature, or damages. As shown in Table 5-3, the different versions of the Kyoto Protocol all pass a cost-benefit test. However, their net benefits are very small relative to other policies. For example, as shown in Table 5-1, the current Kyoto Protocol (without the United States) has net benefits of around $0.15 trillion, compared with $3.4 trillion for the efficient policy. Moreover, once the inefficiencies of the different versions of the Protocol are included, they are unlikely to pass even the minimal cost-benefit test used here." (p. 199-200)
    - More optimistic interpretation is that KP is an awkward first step on the road to a more efficient international agreement
- **Even optimal policies represent very large revenue transfers (about 2% of world consumption) from consumers to producers (if permits are given away) or to governments (if constraints are taxed)**
- "In the author's view, the best approach is one that gradually introduces restraints on carbon emissions. One particularly efficient approach is internationally harmonized carbon taxes—ones that quickly become global and universal in scope and harmonized in effect. **A sure and steady increase in harmonized carbon taxes may not have the swashbuckling romance of a crash program, but it is**

also less likely to be smashed on the rocks of political opposition and compromise. Slow, steady, universal, predictable, and boring—these are probably the secrets for successful policies to combat global warming." (p. 204)

Global Climate Change: A Challenge to Policy, Kenneth J. Arrow, Economist's Voice, 2007 (available from The Berkeley Electronic Press at www.bepress.com/ev)

- Provides a methodological critique of the Stern Report, correcting for futurity and uncertainty discounting, which was neglected within the Stern Report.
- Arrow concurs with fundamental conclusion of the Stern Report, noting "we are much better off to act to reduce CO2 emissions substantially than to suffer and risk the consequences of failing to meet this challenge."
- Available policies are essentially ways to prevent GHGs from entering the atmosphere or to reduce their magnitude.
    - 65% of GHG production comes from the use of energy, with the remaining coming from wastes, agriculture, and land uses.
    - A number of behavioral changes would mitigate this problem:
        - Shifting to fuels which have higher ratios of useful energy to CO2 emissions (e.g., from coal to oil or oil to natural gas);
        - Developing more energy efficient technologies;
        - Shifting demand away from energy-intensive products to less energy intensive substitutes;
        - Planting trees and reducing deforestation;
        - Pursuing an "unproven but apparently feasible" policy of sequestering CO2 in underground reservoirs;
    - Two important factors differentiate global climate change from other environmental problems.
        - First, emissions of CO2 and other GHGs are almost irreversible, due to the time they reside in the atmosphere (measured in centuries). Thus, reducing emissions of CO2 and other GHGs today is "very valuable to humanity in the distant future" (p. 3).
        - Second, global climate change is indeed a global problem, because GHG emissions travel around the world within a few days. Obviously, this means that a single nation is limited in their remedial ability; yet since the US produces 25% of the world's CO2, a change in policy could make a large difference.
- Because of the harm GHG emissions cause to the environment, global climate change can be viewed as a problem of the global commons. To decide whether public policy is warranted, a benefit-cost analysis is used.
    - Two aspects of the benefit-cost calculation are critical (1) an allowance for uncertainty and (2) how one treats future outcomes relative to current ones.
    - Benefit-cost analysis shows that the benefits of acting today to mitigate GHG emissions are greater than the costs, even with absurdly high rates of future discounting.
    - Therefore, with the Stern Review's estimates of future benefits and costs, policies enacted today to mitigate GHGs passes a benefit-cost test. Thus, "there can be little serious argument over the importance of a policy of avoiding major further increases in combustion by-products (i.e., GHGs)" (p. 5).

Policy Options for Reducing CO_2 Emissions, Congressional Budget Office (CBO) Study, February 2008 (available at CBO's web site: www.cbo.org).

- [Staff note: this study was one of the key references for material in "Climate Change Policy: Overview of Options to Reduce GHG Emissions," a powerpoint presentation at April 9, 2008, meeting of the GHG Policy Committee.]
- Compares market-based approaches (tax, cap-and-trade, and hybrid cap-and-trade) on the basis of (1) efficiency in maintaining a balance between the uncertain benefits and costs of reducing CO2 emissions, (2) ease or difficulty of implementation, and (3) possible interactions with other countries' policies—that is, the potential to ensure that U.S. and foreign policies produce similar incentives to cut emissions inside and outside the U.S.
- Appendix A includes good discussion of two major existing U.S. cap-and-trade programs to reduce emissions of sulfur dioxide and nitrous oxide.

Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions, **Congressional Budget Office (CBO) Study, September 2006 (available at CBO's web site: www.cbo.org)**

- Provides analysis of policy options for reducing GHG emissions.
- Projected impacts of global climate change are necessarily couched with high degrees of uncertainty, due to uncertainties in both costs and benefits.
    - Therefore, policymakers face the challenge of implementing "policies that balance the uncertain costs of restraining emissions against the benefits of avoiding uncertain damages from global warming" (p. 1).
- Climate change involves two distinct "market failures" that prevent unregulated markets from achieving the appropriate societal balance between fossil fuel use and damage done to the environment.
    - First, the external costs of GHG emissions are not reflected in the prices which are paid for goods and services that produce them.
    - Second, firms under invest in research and development because innovations yield "spillover" benefits (benefits to society that do not translate into profits for the innovating firm).
- An efficient response to these two market failures is likely to involve two separate policies:
    - Use of pricing policies designed to directly reduce carbon emissions by providing disincentives for their use, thus changing consumer behavior.
    - Increased federal support for R&D of technologies which restrain the growth of GHG emissions, and thus provide spillover benefits.
- These two policies are not mutually exclusive; indeed, both policies could be enacted such that each policy enhances the other.
    - Policies directed toward increasing the costs of emitting CO2 encourage firms to invest in current carbon-reducing technologies as well as R&D for new ones, in which increased federal support for new technologies would augment.
- Chapter 2, Policies for Reducing Carbon Emissions, summarizes price-based policies—taxes or cap-and-trade (described elsewhere in this annotated summary).
        - Carbon pricing policies encourage cost-effective reductions by providing uniform incentives to all consumers (firms, households, governments, and other organizations).
            - "In general, gradually rising prices have been found to be most efficient – that is, most likely to result in a pattern of reductions that would best balance costs and benefits over the long run" (p. 8,10)
            - The effects of pricing policies on the research and development of new technologies is discussed in Box 2-2 on pages 8 and 9.
    - Federal support could be given at all stages of R&D; however, the most cost-effective support would be that which is directed towards technologies in the early stages of development.

        - "The role of basic research is likely to be particularly large in developing fundamentally new technologies that are a long way from the marketplace but that could provide large amounts of carbon-free energy, or carbon sequestration, at a low cost." (p. 11)
        - Such support is not without its downfall; though, as such funds would have to be directed from other projects, and additionally may lead to a "crowding out" of R&D in other sectors of the economy.
- **Chapter 3, The Effectiveness of Policy Approaches,** uses policy-simulation models to evaluate benefits and costs of price-based policies and support for R&D.
    - Although simulation models are currently the best method of analyzing policy implementation, they are filled with uncertainties.
        - Key uncertainties associated with measuring the costs of policy options include: (1) the magnitude of emissions in the absence of policies, (2) the costs of achieving a given reduction in emissions and, (3) the effectiveness of policy tools in bringing about the lowest-cost reductions and/or stimulating the development of new technologies.
        - Key uncertainties associated with measuring the benefits of policy options include: (1) the effect of reductions in carbon emissions on the average global temperature, (2) the effects increased temperatures have on the climate (e.g. rainfall, severity of storms, and sea level), (3) the effects climate change has on "natural and human systems" (e.g. crops, property, species, and human health), and the amount policy-induced reductions will decreased said effects.
        - "Given the tremendous uncertainties involved in measuring policy costs and benefits, quantitative recommendations about the most efficient levels of prices or R&D subsidies are liable to be highly inaccurate" (p. 16).
    - To evaluate the costs and benefits of potential climate change policy, three published models are consulted.
        - All three models concur "that a combination of the two approaches (pricing and R&D policy) would be necessary to reduce carbon emissions at the lowest possible cost" (p. 16)
        - The models consulted do not address the possibility that greenhouse gases could build up to a critical level, thus "trigger(ing) a rapid increase in damages," (p. 17) as pricing policies would reduce near-term emissions.
            - However, near-term pricing policies have value even under such circumstances; "Near-term reductions in emissions could delay the crossing of a critical threshold and thus the point at which severe damages might occur" and "allow time for fundamentally new technologies to be developed and put in place" (p. 16-18).
    - This study is limited in that it only looked at policies designed to reduce emissions in the United States. "However, the causes and consequences of climate change are global, and the most cost-effective mitigation policies would require coordinated international efforts." (p. 19)
        - If carbon pricing policies are not matched by other countries, affected industries may relocate to countries without such policies, negating the policies' objective.

National Climate Policy: Choosing the Right Architecture, Robert Repetto, Yale School of Forestry & Environmental Studies, June 2007

- Discusses the importance of designing policy that will reduce emissions and keep economic impacts to a minimum.

- Policies adopted precipitously or through political negotiations may result in unintended consequences or costs being higher than necessary.
    - estimates that, over a decade, excess cost of inferior policy could be $1.75 trillion or more (enough to fund the Social Security shortfall or eliminate the federal deficit)
    - "It is inconceivable that a spending or tax proposal implying costs of $1.75 trillion over a decade could pass the Congress and be signed into law without extensive scrutiny, analysis, and debate. However, it is quite conceivable that political horse-trading in some Congressional committee room by legislators or even by their staff could result in decisions based largely on political expediency that could entail excess costs of that magnitude."
- Describes risk of "policy lock-in," the tendency for bad policies to stay in place once established, and notes several reasons for reluctance to change once a policy is established:
    - unwillingness to write off institutional and administrative investments in support of bad policy,
    - new policy learning curve, which gives psychological and cost advantages to familiar (bad) over new and unfamiliar approach, and
    - most importantly, policies engender interests that benefit from the policy continuing and who will lobby against change.
- Because excess costs of inferior policy are so high and long-lived and changing to a better policy is difficult, it is critical to adopt a superior policy (e.g., one that is both effective and cost-effective) the first time, even if political expediency leads in another direction.
- Advocates an upstream cap-and-trade system:
    - limits U.S. sales of fossil fuels, whether from domestic or foreign sources,
    - first sellers of such fuels would be required to hold permits, with enforcement at refinery gate (petroleum), first distribution point (natural gas), mine shipping terminus (coal), and at the port (imports)
    - permits would be based on carbon content of each fossil fuel type and tradable among first sellers
    - reductions imposed through gradual reduction in available permits
- Advantages of upstream cap-and-trade system include:
    - comprehensive coverage: will control virtually all emissions of carbon dioxide,
    - reduces risk of "leakage"
    - more efficient (e.g., cost effective) than a policy that concentrates reductions only on some sectors
    - encourages continual innovation by providing clear economic incentive for development and deployment of alternative energy technologies
    - stimulates energy efficiency technologies and investments throughout economy
    - easy to monitor and enforce: estimated that there will be only about 2,000 permit holders whose sales of fossil fuels will be monitored
    - fairness/equity issues: by minimizing economic impacts and spreading them broadly throughout economy, an upstream is more fair; regressive effects can be easily offset if a large percentage of permits are auctioned (rather than distributing very valuable, salable asset free of charge to sellers of fossil fuels) and revenue used to cushion impacts on relatively vulnerable households (e.g., expansion of earned income tax credit, reduction of income tax at the low end); additional revenue could be use to reduce marginal tax rates
        - "Many economic studies have concluded that recycling auction revenues through offsetting tax cuts increases the cost-effectiveness of a cap-and-trade program."
        - Because upstream regime will limit sales and drive up prices, sellers would have little need for further compensation (in the form of free permits) for loss in sales

  - politically viability: relatively simple to explain to electorate and because the "cap's effects on prices of various commodities and services will be brought about through market processes, not a government edict, ... will have political implications more like those of environmental regulations, which also generally result in higher costs and prices, but which are strongly supported politically, in part because the prices effects are not readily perceptible."
- Details specific design features: (1) exemptions for exports and non-fuel uses, (2) duration and banking of permits, (3) expansion to include other GHGs, carbon capture and storage, (4) linkage to other systems, domestic and international, (5) targets and timetables, (6) elimination of price cap/ safety valve.
- **Energy subsidies:** "American energy markets are distorted by subsidies of all kinds whose "net effect is a complete mystery, except that they are very likely to raise domestic energy production and consumption."
  - under upstream cap-and-trade system, effects of subsidies are negated
  - subsidies could be replaced by grandfathered permit allocations, the value of which would provide compensation for the loss of subsidies
  - "similarly, the higher returns afforded to producers of energy alternatives because of higher fossil fuel prices would compensate them for the loss of their subsidies."
- Competitiveness issues: "numerous studies have found either no or negligible impacts from international differences in environmental standards on patterns of trade, investment, or industrial location."
  - trade and investment flows influenced primarily by differences in labor costs, access to raw materials, proximity to growing markets
  - it is important for U.S., along with other developed countries, to negotiate with China, India, Mexico, and Brazil for significant participation and cooperation in next round of GHG emissions reductions
- Few of the legislative proposals introduced so far are based on comprehensive upstream approach.

***Global Climate Change: What is to be Done? An Economic Perspective,* Robert N. Stavins, Harvard Electricity Policy Group (HEPG), June 2007 (available at HEPG's web site: http://www.hks.harvard.edu/hepg)**

- The Kyoto Protocol's (KP) first commitment period begins in 2008.
  - However, "Even if the United States had participated, the Protocol's direct effects on climate change would be very small to non-existent." (p. 5)
  - For future efforts, a more credible international approach is needed.
- KP fell short in many areas: (1) costs were at least four times greater than that which was needed, due to the exclusion of developing countries, (2) KP offered trivial benefits, and no long-term solution, and (3) short-term targets for the United States were overly ambitious.
  - In all, KP was "too little, too fast."
- Future policies should learn from the failures of KP, and incorporate the following:
  - Involvement of all key nations,
  - A long-term structure that reaches reasonable goals in the appropriate amount of time,
  - And include an emphasis on market-based instruments.
- With regard to market-based instruments, most recent proposals feature cap-and-trade policies; this is partly due to economic theory, but mainly due to policy-makers experience with such policies in the following programs: (1) Leaded Gasoline Phaseout in the 1980s, (2) SO2 Allowance Trading Program

since 1995, (3) European Union Emissions Trading System, (4) Northeast states' Regional Greenhouse Gas Initiative, and (5) California's emerging proposal to implement AB 32

- According to the EIA, a $14/ton carbon tax/allocation would lead to a 9% reduction from the base-line model by 2030, with a $50/ton carbon tax/allocation increasing this to 29% (essentially capping emissions at 2005 levels).
    - Furthermore, these policies discourage the implementation of coal-fired power plants, with large decreases in the number built until a value of about $14/ton; coal will still be the used in increasing amount until a carbon tax/allowance of $30/ton is implemented.
- "No matter who occupies the White House, a KP-type treaty will not be submitted to the U.S. Senate for ratification." (p. 14)

***What Will it Cost to Protect Ourselves from Global Warming?: The Impacts on the U.S. Economy of a Cap-and-Trade Policy for Greenhouse Gas Emissions,* Nathaniel Keohane and Peter Goldmark, Environmental Defense Fund, 2000 (http://www.edf.org/documents/7815_climate_economy.pdf).**

- Primary thesis is that economic impacts will be relatively small: "ambitious climate policy is affordable."
- Emphasizes the importance of not delaying and the increasing costs associated with delay. Also stress importance of U.S. leading the international effort.
- Reiterates the importance of harnessing "market forces—the most powerful engine of growth and opportunity" and the "enormous cost savings that can be realized if we employ market-based policies... to achieve emissions reductions, rather than prescribing 'command-and-control' approaches such as mandatory technology requirements." (p. 5-6)
- They review several recently published economic analyses of climate policies, one set of which looks at Lieberman-Warner and Lieberman-McCain, the other set of studies explored the economic impacts of comprehensive, economy-wide climate policy. From this review, they note that:
    - **Estimated impact on GDP for 2010-2030 ranges from 0.23% to 2.15% of present value GDP.**
    - **Estimated impact on GDP for 2030-2050 ranges from 0.59% to 3.59% of present value GDP.**
    - analysis of impacts on household energy bills factors in expected drop in consumption in response to higher prices.
    - Estimated impact on number of jobs is zero.
- Climate change policy will not lead to economic doom.
- Elements of a well-designed climate policy include:
    - Predictable regulation of emissions, with long time horizon, that ends up with reductions of 70% to 80% below current levels
    - "Transparent, fairly enforced, economy-wide cap-and-trade system that rewards innovation and punishes inefficiency in the marketplace and permits a wide range of offsets to drive the price of reducing emissions down."
    - "Removal of barriers and subsidies that artificially choke off the flow of investment in new technologies and processes."
    - "Measures to protect the poorest families."
- Consumer's Guide to Economic Models, Appendix A.

***The Economic Costs of the Lieberman-Warner Climate Change Legislation*, The Heritage Foundation, 2008 (available online at http://www.heritage.org/research/EnergyandEnvironment/upload/cda_0802.pdf)**

- Evaluates the potential economic effects of Lieberman-Warner (S. 2191) by constructing three models: (1) a baseline model showing growth of the economy without implementation of Warner-Lieberman; (2) a generous model that assumes that carbon capture and storage (CCS) becomes ready for widespread implementation within 10 years; and (3) a "reasonable" model that assumes CCS technologies do not become commercially viable during the 20-year forecast interval.
- **When comparing the "generous" (best-case) model to the baseline model**, there is an initial boost to GDP (gross domestic product) due to capital investments, which subsides by 2018, leading to a comparative loss in GDP of $94 billion by 2020, $129 billion by 2025, and $111 billion by 2030 (all inflation adjusted to 2006 dollars).
    - **Cumulative GDP losses are $1.7 trillion (2006 dollars), with comparative job losses exceeding a half a million by 2030.**
        - Hardest hit is the manufacturing sector, with employment declining by 14% compared with baseline model.
    - Increased energy costs results in a $47 billion reduction to personal after-tax income by 2015 compared to the base-line model, with this reduction growing to $50.7 billion by 2030 (all inflation adjusted 2006 dollars).
    - The average household can expect an additional $467 (2006 dollars) on each year's utility bill over projections within the baseline model, or $8,870 (2006 dollars) extra spent on energy over the years 2012 to 2030.
    - **When the "reasonable" model is compared to the baseline model**, there is no initial boast to GDP, and losses reach $330 billion by 2025 and $436 billion (2006 dollars) by 2030.
    - **Cumulative GDP losses are $4.8 trillion (2006 dollars) by 2030, with a million fewer jobs than the baseline model.**
    - Disposable incomes also average $68 billion below the baseline model over the 22-year time frame.
    - The models suggests that CCS technologies and retrofits become economically viable at a carbon tax threshold of $50 per ton; natural gas becomes a cost effective replacement for coal at a tax threshold of $30 to $40; and with a tax of $30 or less, coal is still the most cost-effective method of energy production.
- The appendix provides information about Global Insight's long-term U.S. macroeconomic model and the assumptions used to create the "generous" and "reasonable" models.